Tennessee Valley Authority, Post Office Box 2000, Spring City, Tennessee 37381-2000

MAY 23 2002

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U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D. C. 20555

Gentlemen:

In the Matter of) Docket No.50-390
Tennessee Valley Authority)

WATTS BAR NUCLEAR PLANT - REQUEST FOR ADDITIONAL INFORMATION (RAI) REGARDING RADIOLOGICAL IMPACT (TAC NO. MB1884)

The purpose of this letter is to provide additional comparative information regarding the radiological impact of irradiating Tritium Producing Burnable Absorber Rods (TPBARs) at WBN. The enclosure to this letter addresses information contained in the Commercial Light Water Reactor (CLWR) Environmental Impact Statement (EIS) (DOE/EIS-0288) and the 1997 NRC Environmental Assessment (FR 97-24219 Filed 9-10-97). This information was requested by the NRC Project Manager on March 11, 2002.

D030

There are no regulatory commitments made by this letter. If you have any questions about this letter, please contact me at (423) 365-1824.

Sincerely,

P. L. Pace
Manager, Site Licensing
and Industry Affairs

Enclosures
cc: See page 3

Subscribed and sworn to before me
on this 23rd day of May 2002

E. Jeannette Long
Notary Public

My Commission expires May 21, 2005

cc (Enclosure):

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ENCLOSURE
TENNESSEE VALLEY AUTHORITY
WATTS NUCLEAR PLANT (WBN)
UNIT 1
DOCKET NO. 390

NRC REQUEST

How the production TPBAR core affects the items in the NRC's September 8, 1997, EA [addressing the insertion of Lead Test Assemblies]?

TVA RESPONSE

See the attached TVA Report, "Review Of Radiological Considerations for Production of Tritium at Watts Bar Nuclear Plant," dated May 8, 2001.

REVIEW OF RADIOLOGICAL CONSIDERATIONS FOR PRODUCTION OF TRITIUM AT WATTS BAR NUCLEAR PLANT

TENNESSEE VALLEY AUTHORITY

May 23, 2002

TABLE OF CONTENTS

BACKGROUND 3

RADIOLOGICAL IMPACT CONSIDERATION 3

CONCLUSION 3

RADIOLOGICAL IMPACTS OF THE PROPOSED CHANGES 4
Tritium 4
Tritium Source Terms 4
TABLE 1 Station Annual Liquid and Gaseous Tritium Effluents (Curies) 4
FIGURE 1 Sequoyah Unit 1 Cycle 10 RCS Tritium Concentration Vs Time 6
TABLE 2 Design Basis Sources of Tritium In The Primary Coolant For The WBN Tritium Production Core Operating Cycle(2,304 TPBARs) 7
TABLE 3 TPC Projected Tritium RCS Source Term Values 7
Tritium Impacts on Station Operation 8
Normal Operation 9
Abnormal Operation 10
Tritium Impacts on Public Dose 10
Normal Operation 11
TABLE 4 Annual Projected Impact of TPC on Effluent Dose to Maximally Exposed Members of the Public and Total Public Dose 11
Abnormal Operation 12
TABLE 5 Projected Impact of Two TPBAR Failure on Effluent Dose to Maximally Exposed Members of the Public and Total Public Dose 13
Solid Radioactive Waste 14
Spent Fuel Generation and Storage 15
Tritium Impacts on Station Accident Analysis 15
Radiological Consequences of Accidents 15
Loss of AC Power 16
Waste Gas Decay Tank (WGDT) Failure 16
TABLE 6 Radiological Consequences of a Non-LOCA Design Basis Accident (rem) 18
Loss of Coolant Accident 19
TABLE 7 Radiological Consequences of a Design Basis Large Break LOCA (rem) 20
Main Steam Line Failure Outside of Containment 21
Steam Generator Tube Failure 21
Fuel Handling Accidents (FHA) 22
TABLE 8 Radiological Consequences of a Fuel Handling Accident (rem) 24
Rod Ejection Accident 24
Failure of Small Lines Carrying Primary Coolant Outside Containment 25

Background

The U.S. Department of Energy (DOE) and the Tennessee Valley Authority (TVA) have agreed to cooperate in a program to produce tritium for the National Security Stockpile by irradiating Tritium Producing Burnable Absorber Rods (TPBARs) at TVA's Watts Bar Nuclear Plant (WBN) and, to the extent necessary, at TVA's Sequoyah Nuclear Plant (SQN).

The environmental impacts of producing tritium at WBN and SQN were assessed in a FINAL ENVIRONMENTAL IMPACT STATEMENT (EIS) FOR THE PRODUCTION OF TRITIUM IN A COMMERCIAL LIGHT WATER REACTOR (DOE/EIS - 0288, March 1999) prepared by DOE. TVA was a cooperating agency in the preparation of this EIS, and adopted the EIS in accordance with 40 CFR 1506.3(c) of the Council on Environmental Quality regulations. TVA's *Record of Decision* (ROD*) and Adoption of the Final Environmental Impact Statement for the Production of Tritium in a Commercial Light Water Reactor* was published in the Federal Register at 65 Fed. Reg. 26259 (May 5, 2000). In addition to the DOE EIS and TVA's ROD, a Tritium Production Core (TPC) Topical Report (NDP-98-181, Rev. 1) was prepared by DOE to address the safety and licensing issues associated with incorporating TPBARs in a PWR. The Nuclear Regulatory Commission's (NRC) Standard Review Plan (SRP) (NUREG-0800) was used as the basis for evaluating the impact of the TPBARs on a reference plant. The NRC reviewed the TPC Topical Report and issued a Safety Evaluation Report (SER) (NUREG-1672) to support plant-specific licensing of TPBARs in a PWR. Previously, the NRC assessed TVA's requested change to the WBN Technical Specifications (TSs) to provide for insertion of four lead test assemblies (LTAs) containing 32 TPBARs into the WBN reactor during Fuel Cycle 2 in a September 8, 1997, LTA Environmental Assessment (EA). After a single cycle of operation the TPBARs were removed from the reactor, stored in the spent fuel pool, and then placed in shipping casks and transported off-site under DOE control.

Radiological Impact Consideration

TVA conducted a review of the DOE EIS, TVA ROD, NRC's LTA EA, and current operational data with a particular focus on evaluating the radiological impacts associated with the irradiation of TPBARs at WBN. Site-specific data collected during recent extended operating cycles (Watts Bar Unit 1 Cycle 3 and Sequoyah Unit 1 Cycle 10) also provided useful data to estimate the impact from tritium production on station radiological conditions. This review addressed both the onsite and offsite potential radiological impacts of tritium production.

TVA's review utilized the DOE EIS and NRC LTA EA as the basis for the specific evaluations and analyses performed for WBN. Extensive analyses and evaluations of the environmental impacts of a CLWR incorporating TPBARS were documented in the DOE EIS. Plant-specific evaluations (and analyses if required) were performed for WBN using the equations and values given in the WBN Updated Final Safety Analysis Report and Offsite Dose Calculation Manual. In addition, the review included identifying any significant differences between the DOE EIS, NRC LTA EA and the WBN Tritium Program license amendment associated with the TPBARs and assessed them for radiological impacts.

CONCLUSION

Upon review of the documents and the analyses described above, as well as the data collected during and after the LTA project, the review determined that there were no significant radiological impacts associated with the WBN tritium production program identified for either the plant staff or the offsite population. All calculated, radiological consequences continue to remain well below NRC regulatory requirements and acceptance criteria.

Radiological Impacts of the Proposed Changes

Tritium

Tritium is a radioactive isotope of hydrogen with a half-life of 12.3 years. Tritium undergoes beta decay, with a maximum energy of 18.6 KeV. The average energy is 5.7 KeV. This low energy limits the maximum range of a tritium beta to about 6 millimeters in air and 0.0042 millimeters in soft tissue. Therefore, the primary radiological significance of exposure to tritium is in the form of internal exposure.

Tritium Source Terms

Regarding tritium sources, in a non-TPC, the production of tritium in the Reactor Coolant System (RCS) is primarily the result of three processes:

- Ternary fission,
- Boron activation, and
- Lithium activation.

A review of Westinghouse Pressurized Water Reactors benchmark tritium data[1] indicates a nominal production/release tritium value of about 870 Ci/y/unit. This nominal value is consistent with the 845 Ci/y unit average tritium effluent total (TABLE 1 below) observed over the past five years (1997 – 2001) at WBN and SQN. In the NRC LTA EA, the NRC licensing calculation, the GALE code, predicts about 250 Ci (9.25 TBq) of tritium in the reactor coolant and tritium releases to the environment from large PWRs are averaging over 600 Ci (22.2 TBq) per year per reactor and ranging as high as 4,000 Ci (148 TBq) per year without exceeding regulatory limits.

[1] Westinghouse Electric Company, October 2000, *Evaluation of Waste Management Issues for Operation with a Tritium Production Core (TPC).*

TABLE 1 Station Annual Liquid and Gaseous Tritium Effluents (Curies)[2]

SQN	LIQUID	GAS	TOTAL	GAS %
1997	1559.00	45.29	1604.29	2.82%
1998	1905.00	83.72	1988.72	4.21%
1999	998.00	34.26	1032.26	3.32%
2000	2832.40	62.65	2895.05	2.16%
2001	1323.60	40.16	1423.33	2.82%
STATION MEAN	1735.51	53.22	1788.73	2.98%
UNIT MEAN	867.76	26.61	894.37	2.98%
EIS REPORTED VALUE	714	25	739	
WBN	**LIQUID**	**GAS**	**TOTAL**	**GAS %**
1997	639.20	2.56	641.76	0.40%
1998	712.58	7.45	720.03	1.03%
1999	368.43	8.58	377.01	2.28%
2000	1116 00	14.70	1130.70	1.30%
2001	933.31	61.71	995.02	6.20%
STATION MEAN	753.90	19.00	772.90	2.46%
UNIT MEAN	753.90	19.00	772.90	2.46%
EIS REPORTED VALUE	639	5.60	644.6	
TVA	**LIQUID**	**GAS**	**TOTAL**	**GAS %**
PWR UNIT MEAN	829.81	24.07	853.88	2.82%
EIS CALCULATED MEAN VALUE	676.5	15.3	691.8	

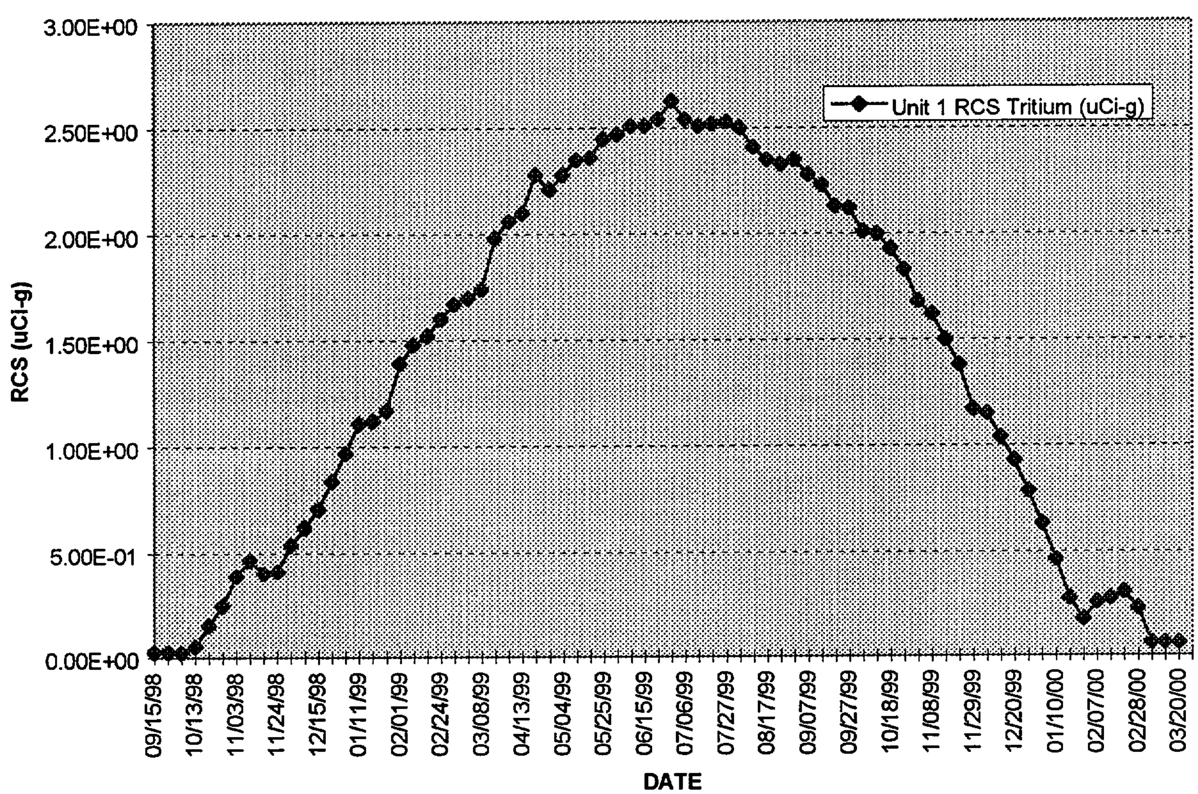
When reviewing station annual tritium effluents, it is important to recognize that plants such as WBN and SQN operate with 18-month fuel cycles which tend to generate more tritium early in the core cycle, owing to higher initial boron concentrations and/or burnable poisons and Integral Fuel Burnable Absorber rods that are required for reactivity control. This results in increasing concentration of tritium in the RCS during the first half of the fuel cycle when discharges from the RCS are relatively small since the amount of feed and bleed necessary to reduce the RCS boron concentration is minimal. These maximum peak tritium concentrations are noted during periods of

[2] Station Annual Radioactive Effluent Release Reports.

continuous operation. However, as the boron concentration is reduced and additional feed and bleed of the RCS is necessary to accommodate boron removal, the amount of primary coolant that is removed increases and the RCS tritium concentrations are reduced over the latter parts of the cycle.

The RCS tritium concentrations from SQN Unit 1 Cycle 10 (continuous operation) are shown below in FIGURE 1 as an example. WBN Unit 1 Cycle 3 (continuous operation) demonstrated a similar pattern.

FIGURE 1 Sequoyah Unit 1 Cycle 10 RCS Tritium Concentration Vs Time



TPBARs are designed and fabricated to retain as much tritium as possible within the TPBAR. Since the TPBAR produced tritium is chemically bonded within the TPBAR, virtually no tritium is available in a form that could permeate through the TPBAR cladding. However, it is assumed that while operating with a TPC, some of the tritium inventory in the TPBARs may permeate the cladding material and be released to the primary coolant. The design goal for this permeation process is less than 1,000 Ci per 1,000 TPBARs per year as a core average. Thus, a single TPBAR may release more than 1 Ci/year, but the total release for 1,000 TPBARs will be less than 1,000 Ci/year. Because the TPC will contain up to

2,304 TPBARs at WBN, the total design basis tritium input from the maximum number of TPBARs is 2,304 Ci/y into the RCS. The NRC EA estimated that the leakage would be less than 6.7 Ci (0.248 TBq) per rod annually. If all 32 of the LTA TPBARs were to adhere to this rate, the annual tritium release to the reactor coolant would be less than 214 Ci (7.93 TBq). The design basis sources of tritium for the RCS, on a fuel cycle basis, are summarized in TABLE 2 below.

TABLE 2 Design Basis Sources of Tritium In The Primary Coolant For The WBN Tritium Production Core Operating Cycle(2,304 TPBARs)

Tritium Source	Curies[3]
Tritium Producing Burnable Absorber Rods	3,456 (design basis value, actual value will be developed based on operating experience)
Ternary Fission	1,770 (design basis value, actual value is estimated to be 350)
Integral Fuel Burnable Absorbers	40
Control Rods	95
Coolant soluble boron	460
Coolant soluble lithium	176
Deuterium	4
Total Design Basis Tritium	6,001

Along with the maximum design basis TPBAR permeation release, a potential release scenario involves the failure of one or more of the TPBARs. Although unlikely, it has been assumed that two TPBARs under irradiation would fail and the entire inventory of tritium would be released to the primary coolant. At the end of the operating cycle, the maximum available tritium in a single TPBAR is calculated to be about 11,600 Ci. While the occurrence of one or two failed TPBARs is considered to be beyond that associated with reasonable design basis considerations, the assumption of two failed TPBARs is discussed in the DOE EIS.

The WBN TPC projected tritium source term values are summarized in Table 3 below:

[3] Westinghouse Electric Company, October 2000, Evaluation of Waste Management Issues for Operation with a Tritium Production Core (TPC).

TABLE 3 TPC Projected Tritium RCS Source Term Values

RCS Tritium Sources	Estimated Annual Tritium Release to RCS (Ci)	Estimated Peak RCS Tritium Concentration (μCi/g)
Non-TPC with nominal tritium release	870[4]	≈ 2.5[5]
Non-TPC with design tritium release	1,826[6]	≈ 5.3
TPC (2,304 TPBARs) with nominal tritium release and design basis permeation from TPBARs	3,170	≈ 9.0[7]
Abnormal Operations		
TPC with nominal tritium release, design basis permeation from TPBARs and one TPBAR failure having instantaneous release at end of operating cycle	14,770	≈ 53[7]
TPC with nominal tritium release, design basis permeation from TPBARs and two TPBAR failures having instantaneous release at end of operating cycle	26,370	≈ 105[7]

TVA has performed an evaluation (see Tritium Impacts on Station Operation, below) and determined that for normal TPBAR operation (permeation only), TVA will maintain normal RCS feed and bleed operation for boron control throughout the cycle. Primary coolant discharge volumes with a TPC will therefore be comparable with current plant practice. The maximum tritium level in the RCS is anticipated to be approximately 9 μCi/g.

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[4] Ibid., Westinghouse Electric Company.

[5] Observed RCS tritium values Watts Bar Unit 1 Cycle 3 and Sequoyah Unit 1 Cycle 10.

[6] Watts Bar Nuclear Plant, *Updated Final Safety Analysis Report (UFSAR).*

[7] Westinghouse Electric Company, October 2000, Evaluation of Waste Management Issues for Operation with a Tritium Production Core (TPC).

Tritium Impacts on Station Operation

Normal Operation

Site-specific data collected during recent extended operating cycles (Watts Bar Unit 1 Cycle 3 and Sequoyah Unit 1 Cycle 10) have provided useful data to estimate the impact` from tritium production on station radiological conditions. The RCS maximum tritium levels noted during the extended operating cycles were ≈ 2.5 μCi/g with a cycle RCS tritium mean of ≈ 1.0 μCi/g. The TVA experienced end of cycle (pre-flood up) RCS tritium values have typically been in the 0.1 - 0.3 μCi/g range for both WBN and SQN. The post-flood up tritium values have typically been in the mid 10^{-2} μCi/g range. The extended cycle tritium peak RCS tritium values of ≈ 2.5 μCi/g have resulted in containment peak tritium Derived Air Concentration (DAC)-fractions of <0.15 for both WBN and SQN with a containment average DAC-fraction of about 0.08. It is understood that containment tritium DAC values are a function of the RCS tritium activity, the transfer of tritium from the RCS to the containment atmosphere (leak rate), and the turnover/dilution of the containment atmosphere through periodic and continuous containment venting and purging.

The projected tritium release to the RCS with a TPC containing 2,304 TPBARs releasing tritium at the design maximum rate will result in about a factor of four increase over the current tritium production rate, that is,

Ratio = (TPC) 3,170 Ci/yr/ (Nominal Core) 870 Ci/yr = 3.6.

Through extrapolation it has been calculated that with no modifications to TVA's current boron-control feed and bleed methodologies, the design basis RCS maximum tritium values will approximate 9 μCi/g with a cycle mean of ≈ 3.6 μCi/g. These values would indicate an estimated containment peak tritium DAC-fraction of ≈ 0.6 and an average containment tritium DAC-fraction of about 0.3. The design basis estimated containment average tritium DAC-fraction equates to an effective dose rate of about 0.7 mrem/h.

Because the primary radiological significance of exposure to tritium is in the form of internal exposure, a potential hazard arises when personnel are exposed to open processes that have been wetted with tritiated liquids. As a result, attention is focused on the design features of the plant that deal with contamination and airborne radioactivity control such as drain and ventilation systems. Using site-specific data collected during recent extended operating cycles, TVA evaluated the additional deep-dose equivalent to select station personnel during TPBAR consolidation and the additional committed effective dose equivalent from possible increased tritium airborne activity in containment. From these data, TVA concluded there will be minimal impact on estimated annual Total Effective Dose Equivalent (TEDE) values.

TVA's current estimate of the TPBAR cycle work scope includes pre-cycle preparation activities, post-cycle removal and handling activities, TPBAR consolidation (including equipment setup and disassembly) and shipping activities, and the processing, packaging, and shipping of the irradiated components for an estimated total of 2,500 man-hours in a 1 mrem/hour radiation field.

The DOE EIS estimated the incremental annual station dose (adjusted for 2,304 TPBARs) to be 0.81 rem and did not include estimated exposure for TPBAR handling and consolidation activities.

The NRC LTA EA estimated that the TPBARs might produce an observable but not dramatic increase in the tritium concentration in the spent fuel pool. According to the NRC's LTA EA, increasing the tritium in the spent fuel pool could increase occupational exposure but, since tritium exposure is not an important contributor to occupational exposure (according to NRC data summarized in NUREG–0713, "Occupational Radiation Exposure at Commercial Nuclear Power Reactors and Other Facilities, 1995", January 1997), the increase would be expected to be negligible. This is consistent with the results reported in the DOE report. The NRC staff then concluded that while the TPBARs could cause some increase in occupational radiation exposure, this increase would be negligible and would not constitute a safety, or an "as low as is reasonably achievable" (ALARA) concern.

TVA estimates that on a TPC basis, this additional TEDE is about 1.7 rem per year for TPBAR handling and consolidation activities (2.5 rem per TPC cycle) and 1.5 rem per year for the additional committed effective dose equivalent from possible increased tritium airborne activity in containment. This estimated additional 3.2 rem per year is an increase of 2.3% of the UFSAR WBN station dose assessment of 149 rem,[8] an amount that remains bounded by the station dose assessment of record. Given this small additional increase, this value is considered insignificant.

Abnormal Operation

In order to consider the unlikely event of TPBAR abnormal operation, TVA established two tritium RCS action levels: > 9 μCi/g and > 15 μCi/g. The lower action level requires more frequent sampling (once/day) to monitor the RCS tritium levels. In the unlikely event that the higher action level is exceeded, TVA would take further action to minimize any onsite and offsite radiological impacts of abnormal RCS tritium levels. These actions may include, but not be limited to, initiating actions to determine cause, more frequent tritium monitoring of RCS as well as other potentially impacted areas such as containment, increased feed and bleed of the RCS to reduce the tritium concentration, and the temporary onsite storage of tritiated liquids to ensure that the discharge concentration limits are met. The action levels described above would be used in response to any abnormal increases of the tritium levels in the RCS.

The EIS estimated the incremental station dose associated with the failure of two TPBARS to be 8.2 rem. TVA considers the additional station dose from the unlikely failure of two TPBARs to be bounded by this estimate.

[8]Watts Bar Nuclear Plant, *Updated Final Safety Analysis Report (UFSAR)*.

Tritium Impacts on Public Dose

Normal Operation

Using the revised TPC source terms, the offsite radiation incremental tritium doses calculated for releases of radionuclides in liquid and gaseous effluents during normal operation are summarized in Table 4. This table also lists WBN's regulatory established radioactive effluent guidelines and the values previously estimated in the DOE EIS.

TABLE 4 Annual Projected Impact of TPC on Effluent Dose to Maximally Exposed Members of the Public and Total Public Dose

	Non-TPC	EIS Data	TPC	NRC Annual Effluent Exposure Guideline
Normal Operations		2,304 TPBARS Incremental Tritium Dose	2,304 TPBARS Incremental Tritium Dose	
Annual Radioactive Gaseous Emissions				
Maximally Exposed Individual (mrem)	7.5	0.0276	1.91	15.00
50-mile Population Dose (Rem)	3.765	0.345	0.765	NA
Annual Radioactive Liquid Emissions				
Maximally Exposed Individual (mrem)	0.720	0.00322	0.000	3.00
50-mile Population Dose (Rem)	1.414	0.437	0.930	NA

The NRC LTA EA estimated that tritium in liquid effluents from WBN would be diluted to a relative low concentration before it reaches even the most highly exposed member of the public; i.e., the release of the entire 214 Ci (7.93 TBq) (from 32 TPBARs) in a year's cooling water would produce an average concentration of only about 0.24 pCi/gm (8.9 Bq/kg) in the receiving water. Consequently, the maximum annual dose to a member of the public would be less than 0.02 mrem (0.2 micro-Sievert) (current estimate is 0.01 mrem/yr). The resulting population dose would be less than 0.09 person-rem (person-cSv). TVA's current estimate for 2304 TPBARs at WBN is 0.930 person-rem.

The NRC LTA EA estimated that a portion of the tritium might be released to the atmosphere. The amount would depend on plant conditions and the manner in which it is operated. If the entire 214 Ci (7.93 TBq) (from 32 TPBARs) were released to the atmosphere, individuals could be exposed via a variety of pathways. These pathways include inhalation and skin absorption, as well as the consumption of meat, vegetables and milk. The total dose by all pathways to the most highly exposed member of the public is calculated to be less than 0.05 mrem (0.50 micro-Sievert). TVA's current estimate for 2,304 TPBARs is 1.91 mrem.

The NRC LTA EA discussed that tritium in the atmosphere also could reach the more highly populated areas in the vicinity of WBN, but the airborne tritium would be diluted even more than would water-borne tritium. Thus the population dose would be smaller from a release to the atmosphere than from a release to the river. TVA's calculations based on 2,304 TPBARs indicate a similar pattern.

Table 4 demonstrates that the calculated WBN station effluent doses are already well below the NRC acceptance criteria, so that the small increase in the reactor coolant activity from the tritium and resultant environmental releases would have a negligible effect on the offsite doses, which continue to remain well below the NRC's acceptance criteria. These values are considered to be insignificant.

Abnormal Operation

In addition to the maximum design basis TPBAR permeation release, a potential release scenario involves the failure of one or more of the TPBARs. It has been conservatively assumed that two TPBARs under irradiation would fail and the entire inventory of tritium would be released to the primary coolant. At the end of the operating cycle, the maximum available tritium in a single TPBAR is calculated to be about 11,600 Ci. While the occurrence of one or two failed TPBARs is considered to be beyond that associated with reasonable design basis considerations, the assumption of two failed TPBARs is discussed in the DOE EIS.

For analysis purposes, it is assumed that this entire inventory of tritium is released to the environment. Even in this extreme case, the doses from liquid and airborne effluent release would remain below applicable ODCM limits, and tritium release concentrations would remain within 10-CFR 20 and ODCM release limits.

The offsite radiation doses calculated for releases of radionuclides in liquid and gaseous effluents for abnormal operation are summarized below. Table 5 also lists WBN's regulatory established radioactive effluent design objectives and the values previously estimated in the DOE EIS.

TABLE 5 Projected Impact of Two TPBAR Failure on Effluent Dose to Maximally Exposed Members of the Public and Total Public Dose

	Non-TPC	EIS Data	TPC	NRC Annual Effluent Exposure Guideline
Abnormal Operations		Two TPBAR Failure Incremental Tritium Dose	Two TPBAR Failure Incremental Tritium Dose	
Annual Radioactive Gaseous Emissions				
Maximally Exposed Individual (mrem)	7.5	0.29	2.58	15.00
50-mile Population Dose (Rem)	3.77	3.4	8.43	NA
Annual Radioactive Liquid Emissions				
Maximally Exposed Individual (mrem)	0.720	0.033	0.08	3.00
50-mile Population Dose (Rem)	1.414	4.4	10.37	NA

Table 5 demonstrates that the calculated WBN station effluent doses are already well below the NRC acceptance criteria, so that even in the unlikely abnormal event of two TPBARs failing and the entire inventory of tritium being released to the primary coolant, the increase in the reactor coolant activity from the tritium and resultant environmental releases would continue to remain well below the NRC's acceptance criteria. These values are therefore considered to be insignificant.

Solid Radioactive Waste

For normal TPC operations, the additional solid waste associated with TPCs that TVA will need to handle will be the base plate and thimble plug assemblies that remain after consolidation. TVA will consolidate and temporarily store these items on-site. Offsite shipment and ultimate disposal is assumed in accordance with agreements between TVA and DOE. The estimated activity inventory associated with these additional irradiated components[9] (112 base plates and 384 thimble plugs) when adjusted to reflect measured dose rate from BP-263, Base Plate with 24 Thimble Plugs following 113 day decay adjusted to 180 days (WBN Survey 010201 #2) is 5,921 curies per cycle (180 day post irradiation decay) or an average of 3,527 curies per year. This represents an increase from the current WBN Updated Final Safety Analysis Report (UFSAR) estimated value of 1,800 Ci per year to approximately 5,530 Ci per year. This increased activity is associated with metal activation products. The estimated disposal volume of this additional solid waste is 50 cubic feet per TPC operating cycle or an average of 33.3 cubic feet per year. The DOE EIS estimated this annual volume to be 15 cubic feet per year. This additional volume is an insignificant increase in the WBN annual estimated solid waste (UFSAR), from 32,820 cubic feet per year to 32,853 cubic feet per year.

TVA's current estimate of the TPBAR cycle work scope includes pre-cycle preparation activities, post cycle removal and handling activities, TPBAR consolidation (including equipment setup and disassembly) and shipping activities, and the processing, packaging, and shipping of the irradiated components for an estimated total of 2,500 man-hours in a 1 mrem/hour radiation field. The DOE EIS estimated the incremental annual station dose (adjusted for 2,304 TPBARs) to be 0.81 rem and did not include estimated exposure for TPBAR handling and consolidation activities. TVA estimates that on a TPC basis, this additional TEDE is about 1.7 rem per year for TPBAR handling and consolidation activities (2.5 rem per TPC cycle). This estimated additional 1.7 rem per year is an increase of 1.1% of the UFSAR WBN station dose assessment of 149 rem,[10] an amount that remains bounded by the station dose assessment of record. Given this small additional ManRem increase for TPBAR handling, consolidation, processing, packaging, and shipping activities, the impact of the increased curies associated with the irradiated components is considered insignificant.

For abnormal TPC operation, where increased feed and bleed operation may be used to reduce tritium levels in the RCS, the increased resins that may result from the increased feed and bleed operation will be stored at TVA in suitable containers. Offsite shipment and ultimate disposal will be according to established agreements between TVA and DOE. The amount of increase associated with abnormal TPC operation is estimated to be an additional 600 Ci and an additional

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[9] Pacific Northwest National Laboratory, 1999, *Unclassified Bounding Source Term, Radionuclide Concentrations, Decay Heat, and Dose Rates for the Production TPBAR, TTQP-1-111 Rev. 1.*

[10] Watts Bar Nuclear Plant, *Updated Final Safety Analysis Report (UFSAR).*

30 cubic feet. This additional volume is an insignificant increase in the WBN annual estimated solid waste (UFSAR), from 32,820 cubic feet per year to 32,850 cubic feet per year

Spent Fuel Generation and Storage

The DOE EIS assessed the environmental impact from the storage of additional spent fuel associated with the production of 3,400 TPBARs. The number of additional fresh fuel bundles per cycle due to tritium production was set at 56. The WBN license amendment establishes 2,304 as the maximum number of TPBARs per cycle. This level of TPBAR irradiation will require approximately 20 additional fresh fuel bundles per cycle. Thus, the tritium production additional spent fuel generation environmental impact is bounded by the DOE EIS impact assessment..

Tritium Impacts on Station Accident Analysis

The American Nuclear Society (ANS) classification of nuclear plant conditions divides plant conditions into four categories according to anticipated frequency of occurrence and potential radiological consequences to the public. The four categories are as follows:

Condition I:	Normal Operation and Operational Transients
Condition II:	Faults of Moderate Frequency
Condition III:	Infrequent Faults
Condition IV:	Limiting Faults

The basic principle applied in relating design requirements to each of the conditions is that the most probable occurrences should yield the least radiological risk to the public and those extreme situations having the potential for the greatest risk to the public shall be those least likely to occur.

TPBARs were designed to withstand the rigors associated with category I through IV events; therefore, no TPBAR failures are predicted to occur during design-basis accidents except for a large break loss of cooling accident (LBLOCA) or a fuel handling accident.

Radiological Consequences of Accidents

The analysis of thyroid, beta-skin, and gamma whole body doses, resulting from events leading to fission product release, are discussed below. To appropriately account for the radiological consequences of the increased tritium in the TPC, TVA included calculated Total Effective Dose Equivalent (TEDE) values in the accident analysis. In those instances where the event was previously analyzed in the DOE EIS, these data are included for comparison. TVA's review confirmed that no significant environmental impact would occur as the result of any design basis accident. Because the calculated station offsite accident doses are already well below the NRC acceptance criteria, any small increase in activity from the tritium and resultant environmental releases would have a negligible effect on the offsite accident doses, which would continue to remain well below the NRC's acceptance criteria. Similarly, the NRC LTA EA concluded that the potential increase in the offsite radiological consequence as a result of accidents has been determined to be negligible. The environmental impacts of any credible accidents are found not to be significant.

Loss of AC Power

The environmental consequences of a loss of normal AC power to the plant auxiliaries involves the release of steam from the secondary system. This will not result in a release of radioactivity unless there is leakage from the RCS to the secondary system in the steam generator. A conservative analysis of the potential offsite doses resulting from this accident is presented with steam generator leakage as the prevalent parameter. This analysis incorporates assumptions of one percent defective fuel, and steam generator leakage prior to the postulated accident for a time sufficient to establish equilibrium specific activity levels in the secondary system. In addition failure of two TPBARs was assumed yielding an RCS Tritium level of 98 μCi/cc. The calculated offsite doses and control room operator doses are substantially below the 10 CFR 100 and 10 CFR 50 Appendix A, General Design Criteria (GDC) limits respectively.

TVA's review confirmed that no significant environmental impact would occur as the result loss of normal AC power to the plant auxiliaries. Because the calculated station offsite accident doses are already well below the NRC acceptance criteria, any small increase in activity from the tritium and resultant environmental releases would have a negligible effect on the offsite accident doses, which would continue to remain well below the NRC's acceptance criteria.

Waste Gas Decay Tank (WGDT) Failure

The gaseous waste processing system is designed to remove fission product gases from the reactor coolant. The system consists of a closed loop with waste gas compressors, waste gas decay tanks for service at power and other waste gas decay tanks for service at shutdown and startup.

The maximum amount of waste gases stored occurs after a refueling shutdown at which time the gas decay tanks store the radioactive gases stripped from the reactor coolant.

The accident is defined as an unexpected and uncontrolled release of radioactive xenon and krypton fission product gases and tritium, in the form of tritiated water vapor, stored in a waste decay tank as a consequence of a failure of a single gas decay tank or associated piping.

This accident was described in the DOE EIS as the non-LOCA Design Basis Accident. The offsite radiation doses calculated for the unexpected and uncontrolled release of the tank's contents are summarized in Table 6 below. This table also lists WBN's regulatory established applicable accident design dose limits and the values previously estimated in the DOE EIS. The DOE EIS assumed that the tritium content of the WGDT would be approximately 345 curies at the time of the postulated failure. In the current analysis TVA has assumed that the tritium content of the WGDT would include 90.7 curies from normal operations and additionally would contain 2,320 curies of tritium from the failure of two TPBARs. This yields a total of 2,410.7 curies of tritium released at the time of the postulated tank rupture.

The 30 day Low Population Zone offsite doses for the realistic and Regulatory Guide 1.24 cases for a WGDT rupture accident were calculated to be substantially below the 10 CFR 100 limits of 25 rem gamma, 300 rem beta, and 300 rem thyroid. The control room operator doses for a WGDT rupture were calculated to be below the 10 CFR 50 App. A GDC 19 limits of 5 rem gamma, 30 rem beta, and 30 rem thyroid.

TVA's review confirmed that no significant environmental impact would occur for a WGDT rupture accident. Because the calculated station offsite accident doses are already well below the NRC acceptance criteria, any small increase in activity from the tritium and resultant environmental releases would have a negligible effect on the offsite accident doses, which would continue to remain well below the NRC's acceptance criteria.

TABLE 6 Radiological Consequences of a Non-LOCA Design Basis Accident (rem)

	Non-TPC	EIS Data	TPC	NRC 10 CFR 100 Exposure Limits
2 Hour Exclusion Area Boundary				
Thyroid(ICRP-2)	0.01806	0.0226	0.01806	300
Beta-Skin	1.342	Not Reported Separately, included in Whole Body Value	1.334	300
Whole Body (Gamma)	0.4994	0.13028	0.4994	25[11]
TEDE	0.2607		0.2921	25
30-Day Low Population Zone				
Thyroid(ICRP-2)	0.004194	0.0053	0.004194	300
Beta-Skin	0.3118	Not Reported Separately, included in Whole Body Value	0.3122	300
Whole Body (Gamma)	0.1160	0.031064	0.1160	25
TEDE	0.06056		0.06784	25
Control Room				NRC 10 CFR 50 Exposure Limits GDC 19
Thyroid(ICRP-2)	0.00822		0.00822	30
Beta-Skin	1.127		1.148	30
Whole Body (Gamma)	0.08576		0.08576	5
TEDE			0.4442	

[11] NUREG 800 Whole Body Limit = 0.500 Rem.

Loss of Coolant Accident

Loss-of-coolant accidents (LOCAs) are accidents that would result from the loss of reactor coolant at a rate more than the capability of the reactor coolant makeup system. LOCAs could occur from breaks in pipes in the reactor coolant pressure boundary up to and including a break equivalent in size to the double-ended rupture of the largest pipe in the reactor coolant system (RCS). Large breaks are defined as breaks in the reactor coolant pressure boundary having a cross-sectional area greater than or equal to 1.0 ft^2. For conservatism, the entire contents of the end of life 2,304 (1.2 grams of tritium (11,600 curies)) TPBARs are assumed by TVA to be released into containment. The SER assumed 0.9 grams of tritium (8,700 curies) and the DOE EIS assumed 1 gram of tritium (9,640 curies).

The total tritium released into containment assumption (for 2,304 TPBARs) was 2.0E+7 curies in the SER, 2.2E+7 curies in the DOE EIS, and 2.7E+7 curies in the current calculation.

In accordance with General Design Criterion 19, the control room ventilation system and shielding have been designed to limit the whole body gamma dose during an accident period to 5 rem, the thyroid dose to 30 rem and the beta skin dose to 30 rem.

This accident was described in the DOE EIS as the LOCA Design Basis Accident. The offsite radiation doses calculated for the loss of reactor coolant at a rate more than the capability of the reactor coolant makeup system are summarized below. This table also lists WBN's regulatory established applicable accident design dose limits and the values previously estimated in the DOE EIS.

The 30 day Low Population Zone and 2-hr Exclusion Area Boundary /Site Boundary LOCA offsite doses were calculated to be below the 10 CFR 100 limits of 25 rem gamma, 300 rem beta, and 300 rem thyroid. The control room operator doses resulting from a LOCA were calculated to be below the 10 CFR 50 App. A, GDC 19 limits of 5 rem gamma, 30 rem beta, and 30 rem thyroid. These data are shown on Table 7 below.

TVA's review confirmed that no significant environmental impact would occur for the LOCA Design Basis Accident. Because the calculated station offsite accident doses are already well below the NRC acceptance criteria, any small increase in activity from the tritium and resultant environmental releases would have a negligible effect on the offsite accident doses, which would continue to remain well below the NRC's acceptance criteria.

TABLE 7 Radiological Consequences of a Design Basis Large Break LOCA (rem)

	Non-TPC	EIS Data Adjusted for 2,304 TPBARs	TPC	NRC 10 CFR 100 Exposure Limits
2 Hour Exclusion Area Boundary				
Thyroid (ICRP-2)	35.42	34.1	33.8	300
Beta-Skin	0.950	Not Reported Separately, included in Whole Body Value	0.955	300
Whole Body (Gamma)	1.596	3.5	1.660	25
TEDE	2.221		2.240	25
30-Day Low Population Zone				
Thyroid (ICRP-2)	11.5	11.0	10.99	300
Beta-Skin	1.640	Not Reported Separately, included in Whole Body Value	1.605	300
Whole Body (Gamma)	1.322	3.4	1.328	25
TEDE	1.230		1.435	25
Control Room				NRC 10 CFR 50 Exposure Limits GDC 19
Thyroid (ICRP-2)	3.548		3.391	30
Beta-Skin	6.965		6.769	30
Whole Body (Gamma)	0.8091		0.7960	5
TEDE	0.9472		1.9083	

Main Steam Line Failure Outside of Containment

The steam release arising from a rupture of a main steam line would result in an initial increase in steam flow, which decreases during the accident as the steam pressure falls. The energy removal from the reactor coolant system causes a reduction of coolant temperature and pressure. In the presence of a negative moderator temperature coefficient, the cool down results in a reduction of core shutdown margin. If the most reactive rod cluster control assembly is assumed stuck in its fully withdrawn position after reactor trip, there is an increased possibility that the core will become critical and return to power. A return to power following a steam line rupture is a potential problem mainly because of the high power peaking factors, which exist, assuming the most reactive rod cluster control assembly to be stuck in its fully withdrawn position. The core is ultimately shut down by the boric acid injection delivered by the safety injection system. In addition failure of two TPBARs was assumed yielding an RCS tritium level of 98 μCi/cc.

An analysis of a potential main steam line failure was performed incorporating the tritium production core, to verify that the control room and offsite doses do not exceed 10 CFR 100 and 10 CFR 50 Appendix A, GDC 19 dose limits. The control room and offsite doses were determined to be within regulatory guidelines.

TVA's review confirmed that no significant environmental impact would occur for a potential main steam line failure. Because the calculated station offsite accident doses are already well below the NRC acceptance criteria, any small increase in activity from the tritium and resultant environmental releases would have a negligible effect on the offsite accident doses, which would continue to remain well below the NRC's acceptance criteria.

Steam Generator Tube Failure

The accident examined is the complete severance of a single steam generator tube. The accident is assumed to take place at power with the reactor coolant contaminated with fission products corresponding to continuous operation with a limited amount of defective fuel rods. The accident leads to an increase in contamination of the secondary system due to leakage of radioactive coolant from the reactor coolant system. In addition failure of two TPBARs was assumed yielding an RCS Tritium level of 98 μCi/cc. In the event of a coincident loss of offsite power, or failure of the condenser dump system, discharge of radioactivity to the atmosphere takes place by way of the steam generator power-operated relief valves (and safety valves if their set point is reached).

Based on TVA's rigorous steam generator tube inspection program, it is considered that the assumption of a complete severance of a tube is somewhat conservative. The more probable mode of tube failure would be one or more minor leaks of undetermined origin. Activity in the steam and power conversion system is subject to continual surveillance and an accumulation of minor leaks, which exceed the limits established in the Technical Specifications, is not permitted during the unit operation.

An analysis of a potential steam generator tube failure was performed incorporating the tritium production core, to verify that the control room and offsite doses do not exceed 10 CFR 100 and 10 CFR 50 Appendix A, GDC 19 dose limits. The control room and offsite doses were determined to be within regulatory guidelines.

TVA's review confirmed that no significant environmental impact would occur in the event of any potential steam generator tube failure. Because the calculated station offsite accident doses are already well below the NRC acceptance criteria, any small increase in activity from the tritium and resultant environmental releases would have a negligible effect on the offsite accident doses, which would continue to remain well below the NRC's acceptance criteria.

Fuel Handling Accidents (FHA)

This accident is defined as dropping of a spent fuel assembly resulting in the rupture of the cladding of all the fuel rods in the assembly despite many administrative controls and physical limitations imposed on fuel handling operations. The analysis considers an FHA occurring in containment with activity passing through the Purge Air Exhaust filters, and an FHA occurring in the fuel handling area of the Auxiliary Building with activity passing through the Auxiliary Building Gas Treatment System filters. The FHA is assumed to occur at 100 hours after shutdown. All the activity is assumed to be released over a two hour period per Safety Guide 25. For the TPC this analysis conservatively assumes that 24 TPBARs are located within the dropped spent fuel assembly and that they rupture and exchange their tritium with the water in the spent fuel pool. Data from Pacific Northwest National Laboratory[12] indicate that the total tritium activity released from 24 TPBARs into water of <200°F would not exceed 84,890 curies. This analysis assumes that the 84,890 curies of tritium are released to the environment over a two hour period.

An FHA occurring in containment results in the largest off site doses, while an FHA in the fuel handling area of the auxiliary building results in the largest control room exposures.

The 30 day Low Population Zone and 2-hr Exclusion Area Boundary /Site Boundary FHA offsite doses for the containment and fuel handling area of the auxiliary building were calculated to be below the 10 CFR 100 limits of 25 rem gamma, 300 rem beta, and 300 rem thyroid. The control room operator doses for the containment and fuel handling area of the auxiliary building resulting from an FHA were calculated to be below the 10 CFR 50 App. A, GDC 19 limits of 5 rem gamma, 30 rem beta, and 30 rem thyroid. These data are shown on Table 8 below.

This accident was described in the DOE EIS as the TPBAR Handling Accident. It included the offsite dose from only the tritium component. The EIS analysis assumed that the entire tritium contents (231,360 curies) of the 24 TPBARs were released to the environment. The DOE EIS did not analyze the dose to the Control Room Operator. For tritium only, the EIS calculated the

[12] TTQP-1-109 Rev 4. January 2001. *UNCLASSIFIED TPBAR RELEASES, INCLUDING TRITIUM.* Pacific Northwest National Laboratory, Richland, Washington.

maximally exposed offsite individual to receive an exposure of 0.028 rem and the average individual in the 50 mile Emergency Planning Zone a dose of 0.000014 rem.

TVA's review confirmed that no significant environmental impact would occur for a potential FHA. Because the calculated station offsite accident doses are already well below the NRC acceptance criteria, any small increase in activity from the tritium and resultant environmental releases would have a negligible effect on the offsite accident doses, which would continue to remain well below the NRC's acceptance criteria.

TABLE 8 Radiological Consequences of a Fuel Handling Accident (rem)

	Non-TPC	EIS Data	TPC	NRC 10 CFR 100 Exposure Limits
2 Hour Exclusion Area Boundary (Containment)				
Thyroid(ICRP-2)	54.50		57.88	300
Beta-Skin	1.182		1.377	300
Whole Body (Gamma)	0.4102		0.4669	25
TEDE	1.759		2.979	25
30-Day Low Population Zone (Containment)				
Thyroid(ICRP-2)	12.66		13.45	300
Beta-Skin	0.2746		0.3198	300
Whole Body (Gamma)	0.09529		0.1085	25
TEDE	0.4085		0.6921	25
Control Room (Spent Fuel Pit, Auxiliary Building)				NRC 10 CFR 50 Exposure Limits GDC 19
Thyroid(ICRP-2)	1.932		2.051	30
Beta-Skin	3.673		4.281	30
Whole Body (Gamma)	0.4455		0.5091	5
TEDE	0.525		4.099	

Rod Ejection Accident

This accident is defined as the mechanical failure of a control rod mechanism pressure housing resulting in the ejection of a rod cluster control assembly and drive shaft. The consequence of this mechanical failure is a rapid positive reactivity insertion together with an adverse core power distribution, possibly leading to localized fuel rod damage. This accident is bounded by the loss-of-coolant accident, discussed above.

TVA's review confirmed that no significant environmental impact would occur for a potential rod ejection accident. Because the calculated station offsite accident doses are already well below the NRC acceptance criteria, any small increase in activity from the tritium and resultant environmental releases would have a negligible effect on the offsite accident doses, which would continue to remain well below the NRC's acceptance criteria.

Failure of Small Lines Carrying Primary Coolant Outside Containment

The analysis of the environmental consequences included the offsite and control room operator dose due to Emergency Core Cooling System (ECCS) leakage outside containment following a LOCA. Most ECCS dose contribution are less than 1% of the baseline dose (with the one exception being the 2-hr Exclusion Area Boundary /Site Boundary beta dose being less than 2% of the total). It has been determined that the offsite doses due to post LOCA ECCS leakage into the Auxiliary building are less than 10 CFR 100 limits of 25 rem gamma, 300 rem beta, 300 rem inhalation and 25 rem TEDE. The control room operator doses are less than the 10 CFR 50, App. A, GDC 19 limits of 5 rem gamma, 30 rem beta, 30 rem inhalation, and 5 rem TEDE. It has been concluded that the ECCS leakage post LOCA will not contribute significantly to the total doses.

TVA's review confirmed that no significant environmental impact would occur due to ECCS leakage outside containment following a LOCA. Because the calculated station offsite accident doses are already well below the NRC acceptance criteria, any small increase in activity from the tritium and resultant environmental releases would have a negligible effect on the offsite accident doses, which would continue to remain well below the NRC's acceptance criteria.